Contents

Chapter 10 Signs, Barriers, Approach Slabs & Utilities

Appendix 10-A

10.1 Sign and Luminaire Supports

10.1.1 Loads

A. General

The reference used in developing the following office criteria is the AASHTO "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals," Fourth Edition Dated 2001 including interims, and shall be the basis for analysis and design.

B. Dead Loads

Sign (incl. stiffeners)	3.25 lbs./ft.^{2}
Luminaire (effective projected area of head = 1.1 sq. ft.)	60 lbs./each
Fluorescent Lighting	3.0 lbs./ln. ft
Standard Signal Head	60 lbs./each
Mercury Vapor Lighting	6.0 lbs./ln. ft
Sign Brackets	Calc.
Structural Members	Calc.
5 foot wide maintenance walkway (incl. sign mounting brackets & handrail)	160 lbs./ln. ft.
Signal Head w/3 lenses (effective projected area = 9.2 sq ft.)	60 lbs. each

C. Wind Loads

A major change in the new AASHTO 2001 Specification wind pressure equation is the use of a 3 second gust wind speed in place of a fastest-mile wind speed used in the previous specification. The 3 second wind gust map in AASHTO is based on the wind map in ANSI/ASCE 7-95.

Basic wind speed of 90 mph shall be used in computing design wind pressure using equation 3-1 of AASHTO Section 3.8.1.

Do not use the Alternate Method of Wind Pressures given in Appendix C of the AASHTO 2001 Specifications.

D. Design Life and Recurrence Interval (Table 3-3, AASHTO 2001)

50 years for luminaire support exceeding 50 ft. in height and overhead sign structures.

25 years for luminaire support structures less than and including 50 ft. in height and traffic signal structures.

10 years for roadside sign structures.

E. Ice Loads

3 psf applied around all the surfaces of structural supports, horizontal members, and luminaires, but applied to only one face of sign panels (AASHTO Section 3.7).

F. Fatigue Design:

Fatigue design shall conform to AASSTO Section 11. Fatigue Categories are listed in Table 11-1. Sign and signal bridges do not require fatigue design. Cantilever structures, poles, and bridge mounted sign brackets shall conform to the following fatigue categories.

Fatigue Category I for overhead cantilever sign structures and bridge mounted sign brackets.

Fatigue Category II for high-level (high-mast) lighting poles in excess of 98 ft. in height

Fatigue Category III for overhead cantilever traffic signal structures

G. Live Load:

A live load consisting of a single load of 500 lb distributed over 2.0 ft. transversely to the member shall be used for designing members for walkways and platforms. The load shall be applied at the most critical location where a worker or equipment could be placed, see AASHTO 2001, Section 3.6.

F. Group Load Combinations:

Sign, luminaire, and signal support structures are designed using the maximum of the following four load groups (AASHTO Section 3.4 and Table 3-1):

Group Load	Load Combination	Percent of * Allowable Stress
I	DL	100
II	DL+W**	133
III	DL+Ice+^{1}/2(W**)	133
IV	Fatigue	See AASHTO Section 11 for Fatigue loads and stress range

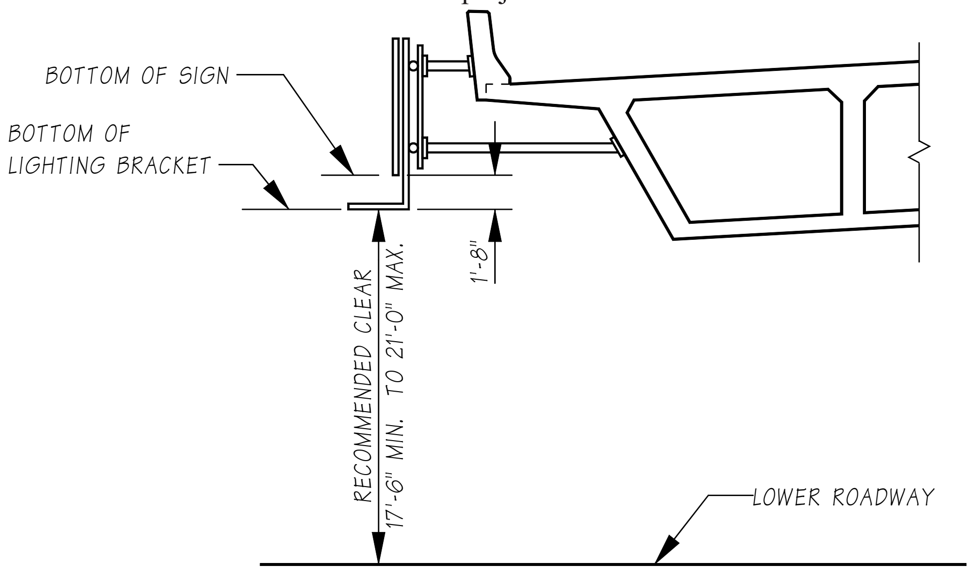
* No load reduction factors shall be applied in conjunction with these increased allowable stress.

** W—Wind Load

10.1.2 Bridge Mounted Signs

A. Vertical Clearance

The bottom of the sign lighting bracket shall be placed a minimum of 17 feet 6 inches and a maximum of 21 feet 0 inches above the lower roadway (see Figure 10-1). The minimum clearance is a requirement of the current electrical code. Region Design may approve greater or lesser clearance on an individual project basis.



Sign Vertical Clearance
Figure 10-1

B. Geometrics

1. Signs should be installed at approximate right angles to approaching motorists. For structures above a tangent section of roadway, signs may be installed parallel to the structure provided the structure skew does not exceed 10°. If the structure skew exceeds 10°, support brackets shall be designed to provide a sign skew of no more than 10° from perpendicular to the lower roadway (see Figure 10-2).

Sign Skew on Tangent Roadway
Figure 10-2

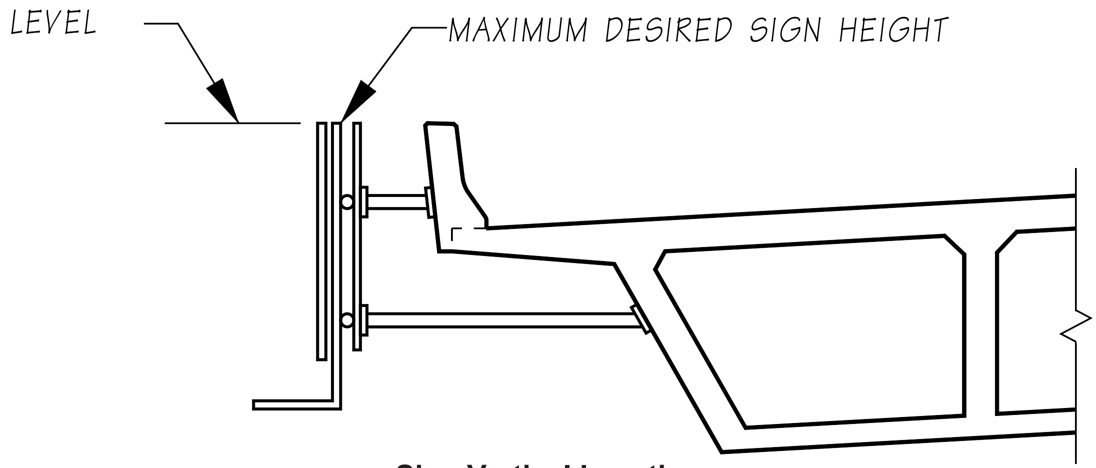
2. For structures located on or just beyond a horizontal curve of the lower roadway, signs may be installed parallel to the structure provided the structure chord-skew does not exceed 10°. If the structure chord-skew exceeds 10°, support brackets shall be designed to provide a sign chord-skew of no more than 10° from perpendicular to the chord-point determined by the approach speed (see Figure 10-3).
3. The top of the sign shall be level.

Sign Skew on Curved Roadway

Figure 10-3

C. Aesthetics

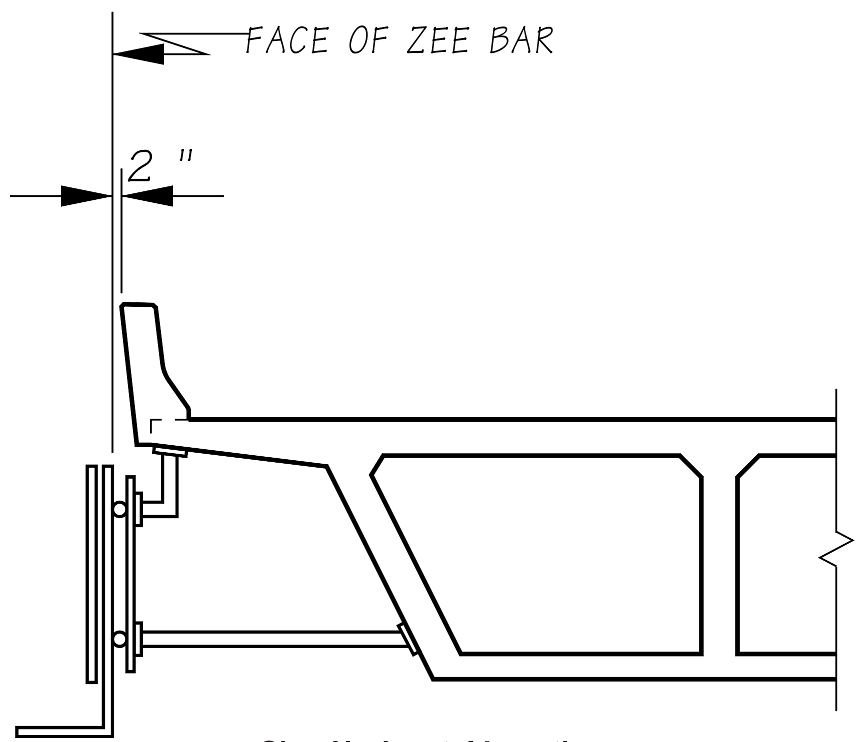
1. Preferably, the top of the sign and its support should not project above the bridge rail (see Figure 10-4).
2. When possible, the support structure should be hidden from view of traffic.
3. The sign support shall be detailed in such a manner that will permit the sign and lighting bracket to be installed level.
4. When the sign support will be exposed to view, special consideration is required in determining member sizes and connections to provide as pleasing an appearance as possible.



Sign Vertical Location
Figure 10-4

D. Sign Placement

1. When possible, the designer should avoid locating signs under bridge overhangs. This causes partial shading or partial exposure to the elements and problems in lifting the material into position and making the required connections. Signs shall never be placed directly under the drip-line of the structure. These conditions may result in uneven fading, discoloring, and difficulty in reading. When necessary to place a sign under a bridge due to structural or height requirements, the installation should be reviewed by the Region Traffic Design Office.
2. When sign support brackets are located on the structure, a minimum of 2 inches of clearance shall be provided between back side of the sign support and edge of the structure. See Figure 10-5.



Sign Horizontal Location
Figure 10-5

E. Installation

Expansion-type concrete anchors are not allowed for attaching sign support brackets to the structure because the loads imposed on the anchors can cause vibration and pull-out. New structures shall use either cast in place ASTM A 307 anchor rods, or resin bonded anchors. Existing structures shall use resin bonded anchors. Resin bonded anchor systems require the following notes to be included in the Plan sheets:

(a) Resin bonded archor system is to be installed using manufacturer recommendations in dry conditions.

(b) Torque resin bonded archor nuts to proof load.

F. Dimensioning

Where shown on the plans, the sign size shall be expressed in terms of horizontal by vertical dimension, i.e., X x Y, where X = horizontal dimension and Y = vertical dimension.

10.1.3 Sign Bridges Mounted on Bridges

A. Design Loads

Design loads for the supports of the sign bridges shall be calculated based on assuming a 12-foot deep sign over the entire roadway width, under the sign bridge. This will account for any signs that may be added in the future. The design loads shall follow the same criteria as described in BDM Section 10.1.1. Loads from the sign bridge shall be included in the design of the supporting bridge.

B. Vertical Clearance

Vertical clearance for sign bridges follow the same requirements as Bridge-Mounted Signs as stated in BDM Section 10.1.2 .

C. Geometrics

Sign structures shall be placed at approximate right angles to approaching motorists. Dimensions and details of sign structures are shown in the Standard Plans G-2, G-2a, G-3, G-3a and BDM sheets 10.1-A1.1, 10.1-A1.2 and 10.1-A2.1, 10.1-A2.2. When maintenance walkways are included, refer to Standard Plan G-6, G-6a and G-6b.

10.1.4 Monotube Sign Structures

A. Sign Bridge Standard Design

Table 10-6 provides the standard structural design information to be used for a Sign Bridge Layout, BDM Sheet 10.1-A1.1; along with the Structural Detail sheets, which are BDM Sheet 10.1-A2.1 and BDM Sheet 10.1-A2.2.

B. Cantilever Standard Design

Table 10-7 provides the standard structural design information to be used for a Cantilever Layout, BDM Sheet 10.1-A1.2; along with the Structural Detail sheets, which are BDM Sheet 10.1-A2.1 and BDM Sheet 10.1-A2.2.

STANDARD MONOTUBE SIGN BRIDGES

SPAN LENGTH	POSTS Ⓤ				BEAM A Ⓤ				BEAM B Ⓤ				BEAM C Ⓤ				
"S"	"H"	"A"	"B"	"T1"	"L1"	"B"	"C"	"T2"	"L2"	"B"	"C"	"T2"	"L3"	"B"	"C"	"T2"	CAMBER
LESS THAN 60'-0"	30'-0" OR LESS	1'-6"	2'-0"	½"	6'-0"	2'-0"	2'-0"	⅜"	0'-0"	-	-	-	13'-0" TO 48'-0"	2'-0"	2'-0"	⅜"	2¾"
60'-0" TO 75'-0"	30'-0" OR LESS	1'-6"	2'-3"	½"	6'-0"	2'-3"	2'-0"	⅜"	9'-0" TO 14'-0"	2'-3"	2'-0"	⅜"	30'-0" TO 35'-0"	2'-3"	2'-0"	⅜"	3¾
75'-0" TO 90'-0"	30'-0" OR LESS	1'-6"	2'-3"	⅝"	6'-0"	2'-3"	2'-0"	⅜"	14'-0" TO 19'-0"	2'-3"	2'-0"	⅜"	35'-0" TO 40'-0"	2'-3"	2'-0"	⅜"	5"
90'-0" TO 105'-0"	30'-0" OR LESS	1'-9"	2'-6"	⅝"	6'-0"	2'-6"	2'-3"	½"	19'-0" TO 26'-6"	2'-6"	2'-3"	½"	40'-0"	2'-6"	2'-3"	½"	6"
105'-0" TO 120'-0"	30'-0" OR LESS	1'-9"	2'-6"	⅝"	6'-0"	2'-6"	2'-3"	½"	26'-6" TO 34'-0"	2'-6"	2'-3"	½"	40'-0"	2'-6"	2'-3"	½"	7½"
120'-0" TO 135'-0"	30'-0" OR LESS	2'-0"	2'-6"	⅝"	6'-0"	2'-6"	2'-6"	½"	34'-0" TO 41'-6"	2'-6"	2'-6"	½"	40'-0"	2'-6"	2'-6"	½"	8½"
135'-0" TO 150'-0"	30'-0" OR LESS	2'-0"	2'-6"	⅝"	6'-0"	2'-6"	2'-6"	½"	41'-6" TO 49'-0"	2'-6"	2'-6"	½"	40'-0"	2'-6"	2'-6"	½"	10½ "

SPAN LENGTH	POST BASE Ⓤ					BOLTED SPLICE #1 L1 TO L2 AND L1 TO L3						BOLTED SPLICE #2 L2 TO L3						MAXIMUM SIGN AREA
"S"	"D1"	"S5"	"S6"	"T3"	"T6"	"S1"	"S2"	"S3"	"S4"	"T4"	"T5"	"S1"	"S2"	"S3"	"S4"	"T4"	"T5"	
LESS THAN 60'-0"	1½"	4	4	2¼"	¾"	5	-	5	-	2"	⅝"	-	-	-	-	-	-	500 SQ. FT.
60'-0" TO 75'-0"	1¾	4	4	2¼ "	¾"	6	-	5	-	2"	⅝"	6	-	5	-	2¼"	¾"	600 SQ. FT.
75'-0" TO 90'-0"	1¾"	4	4	2½"	¾"	6	-	5	-	2"	⅝"	6	-	5	-	2¼"	¾"	750 SQ. FT.
90'-0" TO 105'-0"	1¾"	4	5	2½"	1"	7	-	6	-	2"	⅝"	7	5	6	4	2½"	1"	750 SQ. FT.
105'-0" TO 120'-0"	1¾"	4	5	2½"	1"	7	-	6	-	2"	⅝"	7	5	6	4	2½"	1"	850 SQ. FT.
120'-0" TO 135'-0"	2"	4	5	2½"	1"	7	-	7	-	2"	⅝"	7	5	7	5	2½"	1"	800 SQ. FT.
135'-0" TO 150'-0"	2"	4	5	2½"	1"	7	-	7	-	2"	⅝"	7	5	7	5	2½"	1"	800 SQ. FT.

Ⓤ NOTE: DENOTES MAIN LOAD-CARRYING TENSILE MEMBERS OR TENSION COMPONENTS OF FLEXURAL MEMBERS

Table 10-6

STANDARD CANTILEVER SIGN BRIDGES

SPAN LENGTH	POST Ⓤ				BEAM A Ⓤ				BEAM B Ⓤ				
"S"	"H"	"A"	"B"	"T1"	"L1"	"B"	"C"	"T2"	"L2"	"B"	"C"	"T2"	CAMBER
LESS THAN 20'-0"	30'-0" OR LESS	1'-6"	2'-0"	3/8"	6'-0"	2'-0"	2'-0"	3/8"	14'-0"	2'-0"	2'-0"	3/8"	2"
20'-0" TO 30'-0"	30'-0" OR LESS	1'-6"	2'-0"	1/2"	6'-0"	2'-0"	2'-0"	3/8"	14'-0" TO 24'-0"	2'-0"	2'-0"	3/8"	3 1/2"

SPAN LENGTH	POST BASE					BOLTED SPLICE						MAXIMUM SIGN AREA
"S"	"D1"	"S5"	"S6"	"T3"	"T6"	"S1"	"S2"	"S3"	"S4"	"T4"	"T5"	
LESS THAN 20'-0"	1 1/2"	4	4	2"	3/4"	5	-	5	-	2"	5/8"	168 SQ. FT.
20'-0" TO 30'-0"	2"	4	4	2"	3/4"	5	3	5	3	2 1/2"	5/8"	252 SQ. FT.

Ⓤ NOTE: DENOTES MAIN LOAD-CARRYING TENSILE MEMBERS OR TENSION COMPONENTS OF FLEXURAL MEMBERS

Table 10-7

C. Monotube BDM Sheet Guidelines

The following guidelines apply when using the Monotube Sign Structure BDM sheets 10-S1-1, 10-S1-2 and 10-S2-1, 10-S2-2.

1. Each sign structure shall be detailed and must specify:
   a. Sign structure base Elevation, Station and Number.
   b. What type of foundation (1, 2, or 3) is to be used for the structure. If Foundation Type 1, 2 or 3 are not used, then the average lateral bearing pressure for each foundation shall be noted on the Layout sheet.
   c. If applicable, label the Elevation View "Looking Back on Stationing".
2. Designers shall verify the cross-referenced page numbers and details are correct.

B. Monotube BDM Quantities

Quantities for structural steel are given in Table 10-8.

Quantities ASTM A572 GR. 50 or ASTM 588	A	B	C	D	E	F	G	H	I
Post (plf)	99	132	132	144	176	204	204	215	215
Base PL (ea)	431	490	490	578	585	654	654	688	688
Beam, near Post (plf)	116	116	116	124	124	139	139	171	195
Span Beam (plf)	116	116	116	124	124	162	185	195	195
Corner Stiff. (ea set)	209	204	204	238	236	312	312	371	369
Splice PL #1 (1 pr)	482	482	482	692	692	892	883	780	780
Splice PL #2 (1 pr)	—	—	482	615	615	718	802	715	780
Brackets (ea)	60	60	60	65	65	69	69	70	70
6" Hand Hole (ea)	18	18	18	18	18	18	18	18	18
6" x 11" Hand Hole (ea)	30	30	30	30	30	30	30	30	30
Anchor Bolt Pl (ea)	175	175	175	185	185	311	311	326	326
Seal Plates (1 bridge)	217	216	316	614	612	770	674	860	860

A) 20' ≤ Cantilever
B) 20' to 30 Cantilever
C) 60' and Less Sign Bridge
D) 60' to 75' Sign Bridge
E) 75' to 90' Sign Bridge
F) 90' to 105' Sign Bridge
G) 105' to 120' Sign Bridge
H) 120' to 135' Sign Bridge
I) 135' to 150' Sign Bridge

Sign Structure Steel Quantities

Table 10-8

10.1.5 Foundations

A. Foundation Types

The Geotechnical Branch shall be consulted as to which foundation type is to be used. Standard foundation designs are provided in WSDOT Standard Plans G-2a and G-3a; and in BDM Section 10.1.5. The following paragraphs describe the four types of foundations detailed in this section of the BDM.

1. The Type 1 Foundation, a drilled shaft, is the preferred foundation for sign, luminaire, and signal supports. The standard drilled shafts are designed for a lateral bearing pressure of 2,500 psf. See BDM Sheet 10.1-A3.1 for Type 1 Foundation standard design information.
2. The Type 2 Foundation is an alternate to Type 1 when drilled shafts are not suitable to the site. Type 2 Foundations are designed for a lateral bearing pressure of 2,500 psf. See BDM Sheet 10.1-A3.2 for Type 2 Foundation standard design information.
3. The Type 3 Foundation is designed for poor soil conditions where the lateral bearing pressure is between 2,500 psf and 1,500 psf. The standard details for both Type 2 and 3 Foundations are found on BDM Sheet 10.1-A3.2. See BDM Sheet 10.1-A3.2 for Type 3 Foundation standard design information.
4. Barrier Foundation Types (1-3) are foundations that include a barrier in the top portion of the Standard foundation. Types 1, 2 and 3 have been modified to include the required Traffic Barrier shape for the project. BDM Sheet 10.1-A4.1 details a double faced "F" shape barrier. BDM Sheet 10.1-A4.2 details a single slope barrier.

Foundation Quantities for BDM Sheets 10.1-A3.1 AND 10.1-A3.2 are described below.

1. Barrier quantities are approximate and can be used for all Foundation Types: (Both single slope or F-shape barriers)

Class 4000 Concrete	0.289 CY/LF (over shaft foundation)
Grade 60 rebar	372 lbs.

2. Miscellaneous steel quantities for all foundation types: (anchor bolts, anchor plate, and template)

   60 feet & under = 1,002 pounds

   61 feet to 90 feet = 1,401 pounds

   91 feet to 120 feet = 1,503 pounds

   121 feet to 150 feet: Barrier mounted sign bridge not recommended for these spans.

3. Type 1-3 Foundation quantities for concrete, rebar and excavation are given in Table 10-9. For Sign Bridges, the quantities shown below are for one foundation and there are two foundations per sign bridge.

Sign Structure Foundation Material Quantities						
	Cantilever Signs		Sign Bridges			
Concrete Cl. 3000 (cu. yard)	20' & Under	20' – 30'	60' & Under	60' – 90'	90' – 120'	120' – 150'
Type 1	6.3	7.5	7.7	9.4	10.6	11.4
Type 2	8.0	10.5	10.0	12.2	14.1	15.0
Type 3	11.1	14.1	13.0	16.1	18.6	20.0
Rebar Gr. 60 Pounds						
Type 1	685	1,027	1,168	2,251	3,256	4,255
Type 2	772	1,233	1,190	1,724	2,385	2,838
Type 3	917	1,509	1,421	2,136	2,946	3,572
Excavation (cu. yard)						
Type 1	9.8	10.9	10.9	12.8	14.1	14.9
Type 2	20.7	25.7	24.6	29.0	32.9	34.6
Type 3	29.0	34.6	32.9	39.0	44.0	47.8

Table 10-9

10.1.6 Truss Sign Bridges: Foundation Sheet Design Guidelines

There are four items that should be addressed when using the BDM Truss Sign Bridge Barrier Foundation sheet (BDM sheet 10.1-A5.1), which are outlined below. WSDOT Standard Plan C-14i is available for use as the single slope barrier version of BDM Sheet 10-S5-1.

1. Determine conduit needs. If none exist, delete all references to conduit. If conduit is required, verify with the Region as to size and quantity.
2. Show sign bridge base elevation, number, "D" dimension and station.
3. Transition section can be 10 feet 0 inches or 12 feet 6 inches.
4. The quantities for the barrier as shown on the sheets are as follows:

Class 4000 concrete	0.185 CY/LF above foundation cap
	0.269 CY/LF outside foundation cap
Gr. 60 Rebar	Varies based on the type of foundation and the "D" dimension.

10.2 Bridge Traffic Barriers

10.2.1 General Guidelines

The design criteria for bridge traffic barriers on structures shall be in accordance with Chapter 13 of the LRFD Bridge Design Specifications adopted by AASHTO.

WSDOT's bridge traffic barrier standard test level is a TL-4.

The WSDOT Bridge and Structures standard for new bridge traffic barriers is a 32-inch high F-Shape concrete barrier. This shape is also the preferred shape by the FHWA. This shall be used on all interstate, major highway routes, and over National Highway System (NHS) routes.

Use of a Single Slope concrete bridge traffic barrier shall be limited to when there is Single Slope concrete barrier on the approach grade to a bridge or for continuity within a corridor. The Single Slope bridge traffic barrier is 34 inches high to be consistent with the heights being used on grade applications. (See WSDOT Design Manual Section 710 for additional background and criteria.)

Use the taller 42-inch high bridge traffic barriers on interstate or freeway routes only in the following circumstances:

- Accident history suggests a need.
- Large trucks make up a significant portion of the ADT
- Adverse roadway geometrics increase the possibility of hitting the traffic barrier at a high angle (such as on ramps for freeway to freeway connections with sharp curvature in the alignment).
- Protection of schools, businesses or other important facilities below the bridge.

In addition, NCHRP Report 350 was adopted by AASHTO to give specific requirements for crash testing of bridge barriers prior to their use on all new or retrofitted bridge structures. The LRFD Bridge Design Specifications differentiate crash test criteria for various test levels depending upon traffic volume, design speed, vehicle mix, and other factors which produce a vast variation in traffic railing performance needs from one site to another.

A list of crash tested traffic barrier can be found thru the FHWA at http://safety.fhwa.dot.gov/fourthlevel/pro_res_road_nchrp350.htm.

Bridge traffic barriers shall be rigidly connected to the bridge deck.

Median bridge traffic barriers shall be either rigidly connected to bridge deck or allow a minimum of two feet of slide distance between the toe of the traffic barrier and the lane pavement marking.

10.2.2 Bridge Railing Test Levels

It must be recognized that bridge traffic barrier performance needs differ greatly from site to site. Barrier designs and costs should match facility needs. This concept is embodied in the LRFD Bridge Design Specifications. Six different bridge railing test levels, TL-1 thru TL-6, and associated crash test/performance requirements are given in Chapter 13 of these design specifications along with guidance for determining the appropriate test level for a given bridge.

10.2.3 Available WSDOT Designs

A. Test Level 2

1. Service Level 1 (SL-1) Weak Post Guardrail

   This bridge traffic barrier is a crash tested weak post rail system. It was developed by Southwest Research Institute and reported in NCHRP Report 239 for low-volume rural roadways with little accident history. We have utilized this design on some of our short concrete spans and on our timber bridges. A failure mechanism is built into this rail system such that upon a 2 kip applied impact load the post will break away from the mounting bracket. The thrie beam guardrail will contain the vehicle by virtue of its ribbon strength. This failure mechanism assures minimum damage, if any at all, to the bridge deck and stringers. The appropriate guardrail approach transition shall be a Case 14 placement as shown on Standard Plan C-2h. For complete details see Appendix 10.4-A1.

2. Texas T-411 Aesthetic Concrete Baluster

   Texas developed this standard for a section of highway that was considered to be a historic landmark. The existing deficient concrete baluster rail was replaced with a much stronger concrete baluster that satisfactorily passed the crash test performance criteria set forth by the NCHRP Report 230. For details visit TXDOT's Bridge and Structures web site at http://www.dot.state.tx.us/brg/default.htm.

Figure 10-10

B. Test Level 4 Traffic Barriers

1. Traffic Barrier – Shape F

   This configuration was crash tested in the late 1960's, along with the New Jersey Shape, under NCHRP 230 and again recently at this test level under NCHRP 350. The steeper vertical shape actually tested better than the New Jersey face and had less of an inclination to roll vehicles over upon impact. The 3" toe of the traffic barrier is the maximum depth that an ACP or HMA overlay can be placed. For complete details see Appendix 10.2-A1 & A2.

2. Traffic Barrier – Single Slope

   This concrete traffic barrier system was designed by the state of California, in the 1990's, to speed up construction by using the "slip forming" method of construction. It was tested under NCHRP 350. WSDOT has increased the height from 32" to 34" to match the approach traffic barrier height. Due to inherent problems with the "slip forming" method of traffic barrier construction WSDOT has increased the concrete cover on the traffic side from 1 ½" to 2 ½". For complete details see Appendix 10.2-A3.

Figure 10-11

3. Pedestrian Barrier

   This crash tested rail system offers a simple to build concrete alternative to the New Jersey and F-Shape configurations. This system was crash tested under both NCHRP 230 and 350. Since the traffic face geometry is better for pedestrians and bicyclists, WSDOT uses this system primarily in conjunction with a sidewalk. For complete details see Appendix 10.2-A4.

4. Oregon 2-Tube Curb Mounted Traffic Barrier

   This is another crash tested traffic barrier that offers a lightweight, see-through option. This system was crash tested under both NCHRP 230 and 350. A rigid thrie beam guardrail transition is required at the bridge ends. For details see the Oregon Bridge and Structure web site at http://www.odot.state.or.us/tsbbridgepub/.

Figure 10-12

C. Test Level 5 Traffic Barriers

1. Traffic Barrier – Shape F 42”

   This barrier is very similar to the 32 inch F-shape concrete barrier in that the slope of the front surface is the same except for height. This barrier and the other bridge traffic barriers within this section have been crash tested for a 50,000 lb. tractor-trailer. For complete details see Appendix 10.2-A5.

   This barrier was used on a portion of the Seattle Access project in Seattle due to the large vehicular mix of large trucks and buses and to protect buildings below the bridge structure. Another application of this barrier is on Bridge No. 101/515E-S due to the roadway alignment's sharp radius curvature.

2. Traffic Barrier – Single Slope 42”

   This crash tested option offers a simple to build alternative to the Shape F configuration. For complete details see Appendix 10.2-A6.

Figure 10-13

10.2.4 Design Criteria

A. Design Values

The WSDOT traffic barriers are reinforced based on the FHWA crash testing program as described in NCHRP Report 350. The reinforcement is based on the AASHTO LFD 10 kip load. This produces a traffic barrier system that is overdesigned when analyzed with AASHTO LRFD criteria and leads to the possibility that the deck overhang is also overdesigned.

In order to prevent this unnecessary overdesign of the deck overhang, the nominal traffic barrier resistance to transverse load, R_W found in AASHTO LRFD Specifications Section A13.3.1 transferred from the traffic barrier to deck overhang need not to be taken 120% of the design force, F_t, required for traffic barrier found in AASHTO LFRD Bridge Design Specifications table A13.2-1.

The deck overhang should be designed in accordance to the requirements of the AASHTO-LRFD Specifications Section A 13.4.2 to provide a flexural resistance M_S, acting coincident with the tensile force T. At the inside face of the barrier M_S may be taken as:

$\dfrac{R_w \cdot H}{L_c + 2 \cdot H}$ for an interior barrier segmen

and

$\dfrac{R_w \cdot H}{L_c + H}$ for an end barrier segmen

However, M_S need not to be taken greater than M_C at the base.

T shall be taken as $\dfrac{R_w}{L_c + 2 \cdot H}$ for an interior barrier segment

And $\dfrac{R_w}{L_c + H}$ for an end barrier segment

The barrier impact design forces transmitted to the deck overhang, not including the dead loads of the traffic barrier and the slab, shall be taken as:

Vehicle Impact Loadings on Traffic Barrier/Cantilevered Deck Overhang

		Type F 32 in		Single Slope		Shape F 42”		Single Slope 42”	
	Parameters	Interior	End*	Interior	End	Interior	End	Interior	End
Traffic Barrier Design	Average Mc (ft-kips/ft)	20.62	20.62	19.39	19.39	29.18	29.18	25.22	25.22
	Mc at Base (ft-kips/ft)	27.24	27.24	26.11	26.11	37.00	37.00	34.52	34.52
	MwH (ft-kips)	42.48	45.98	44.72	42.17	97.83	96.91	83.87	79.14
	Lc (ft)	8.61	4.75	9.19	4.79	14.48	9.25	14.45	9.19
	Rw (kips)	133.09	73.48	125.79	65.53	241.47	154.33	208.16	132.49
	Ft (kips)	54.00	54.00	54.00	54.00	124.00	124.00	124.00	124.00
Deck Overhand Design	1.2*Ft (kips)	64.80	64.80	64.80	64.80	148.80	148.80	148.80	148.80
	Design Rw (kips)	64.80	64.80	64.80	64.80	148.80	148.80	148.80	132.49
	Rw*H/(Lc+xH) (ft-kips/ft)	12.40	23.29	12.36	24.09	24.24	40.83	24.28	36.53
	Design Ms (ft-kips/ft)	12.40	23.29	12.36	24.09	24.24	37.00	24.28	34.52
	Design T (kips/ft)	4.65	8.74	4.36	8.50	6.93	11.67	6.94	10.44
Deck to Barrier Reinforcement	As required (in^2/ft)	0.29	0.56	0.29	0.58	0.44	0.68	0.50	0.72
	As provided (in^2/ft)	0.41	0.62	0.41	0.62	0.66	0.75	0.66	0.75
	S1 Bars	#5 @ 9in	#5 @ 6in	#5 @ 9in	#5 @ 6in	#6 @ 8in	#6 @ 7in	#6 @ 8in	#6 @ 7in
Weight Area	W (lbs/ft)	472.5		505.3		729.0		692.2	
	A (in ^2)	425.2		454.8		656.1		623.0	

* Traffic barrier cross sectional dimensions and reinforcement used for calculation of the end segment parameters are the same as interior segments. Parameters for modified end segments shall be calculated per AASHTO_LRFD article A13.3, A13.4, and the WSDOT LRFD BDM.

When an HMA overlay is required for initial construction, increase the weight for Shape F traffic barrier. See section 10.2.4.C for details.

B. Geometry

These traffic barriers have been crash tested and shall not be significantly modified unless they are retested to NCHRP 350 or approved by the FHWA as described in Chapter 13 of the AASHTO Specifications. The traffic face geometry is part of the crash test and shall not be modified. Contact WSDOT Bridge and Structure's Traffic Barrier Specialist for further guidance.

Thickening of the traffic barrier is permissible for architectural reasons. Concrete clear cover must meet minimum concrete cover requirements, but can be increased to accommodate rustication, groves, or patterns and must meet minimum concrete cover requirements.

C. Standard Detail Sheet Modifications

When designing and detailing a bridge traffic barrier on a superelevated bridge deck, the following guidelines shall be used:

- For bridge decks with a superelevation of 8% or less, the traffic barriers (and the median barrier, if any) shall be oriented perpendicular to the bridge deck.
- For bridge decks with a superelevation of more than 8%, the traffic barrier on the low side of the bridge (and median barrier, if any) shall be oriented perpendicular to an 8% superelevated bridge deck. For this situation, the traffic barrier on the high side of the bridge shall be oriented perpendicular to the bridge deck.

The standard detail sheets are generic and may need to be modified for each project. The permissible modifications are:

- Removal of the electrical conduit, junction box, and deflection fitting details.
- Removal of design notes.
- If the traffic barrier does not continue on to a wall, remove W1 and W2 rebar references.
- Removal of the non-applicable guardrail end connection details and verbiage.
- If guardrail is attached to the traffic barrier use either the thrie beam design "F" detail or the W-beam design "F" detail.

If the traffic barrier continues off the bridge, approach slab, or wall, remove the following:

- Guardrail details from all sheets
- Conduit end flare detail
- Modified end section detail and R1A or R2A rebar details from all sheets
- End section bevel
- Increase the 3" toe dimension of the Shape F traffic barriers up to 6" to accommodate HMA overlays.

D. Miscellaneous Design Information

- Show the back of Pavement Seat in the "Plan – Traffic Barrier" detail.
- At roadway expansion joints, show traffic barrier joints normal to centerline, except as shown on sheets in Chapter 9 Appendix.
- When an overlay is required, the 2'-8" minimum dimension shown in the "Typical Section – Traffic Barrier" shall be referenced to the top of the overlay.

When bridge lighting is part of the contract, include the lighting bracket anchorage detail sheet.

10.3 At Grade Cast-in-Place Barriers

10.3.1 Median Barriers

Cast-in-place (CIP) barriers at grade are sometimes required in median areas with different roadway elevations on each side. Both a safety - shape and an F-shape CIP median barrier have been crash tested successfully with a 2'- 0" or less difference in grade elevations. The Single Slope traffic barrier can be used for a difference in grade of up to 10", see the WSDOT Standard Plans for details. The minimum length will be based on general stability requirements. If a greater difference in elevations is required then the barrier shall be designed as a wall using the AASHTO LRFD barrier loading.

The top of the median traffic barrier shall have a minimum width of 6". If a luminaire or sign is to be mounted on top of the median traffic barrier, then the width shall be increased to accommodate the mounting plate and 6" of clear distance on each side of the luminaire or sign pole. The transition flare rate shall follow WSDOT Design manual.

10.3.2 Shoulder Barriers

At grade CIP shoulder barriers are sometimes used adjacent to bridge sidewalk barriers in lieu of standard precast Type 2 barriers. This barrier cross section has an equivalent mass and resisting moment for stability as the embedded double face New Jersey Traffic Barrier, which has been satisfactorily crash tested. A wire rope and pin connection shall be made at the bridge barrier end section per Standard Plan C-8. If a connection is made to an existing traffic barrier or parapet on the bridge, 15-inch long holes shall be drilled for the wire rope connection and shall be filled with an adhesive resin.

10.4 Bridge Traffic Barrier Rehabilitation

10.4.1 Policy

The bridge traffic barrier retrofit policy is: “to systematically improve or replace existing deficient rails within the limits of roadway resurfacing projects”. This is accomplished by:

- Utilizing an approved crash tested rail system that is appropriate for the site or
- Designing a traffic barrier system to the strength requirements set forth by Section 2 of AASHTO Standard Specifications for Highway Bridges, 17^{th} edition.”

10.4.2 Guidelines

A strength and geometric review is required for all bridge rail rehabilitation projects. If the strength of the existing bridge rail is unable to resist an impact of 10 kips or has not been crash tested, then modifications or replacement will be required to improve its redirectional characteristics and strength. Bridges that have deficient bridge traffic barriers were designed to older codes. The AASHTO LFD load of 10 kips shall be used in the retrofit of existing traffic barrier systems constructed prior to the year 2000. The use of the AASHTO LRFD criteria to design traffic barrier rehabs will result in a bridge deck that is susceptible to damage from a traffic barrier impact load and increase the retrofit cost due to expensive deck modifications.

10.4.3 Design Criteria

Standard thrie beam guardrail post spacing is 6’- 3” except for the SL-1 Weak Post, which is at 8’- 4”. Post spacing can be increased up to 10’- 0” but the thrie beam guardrail has to be nested or doubled up.

Except as otherwise noted, gaps in the guardrail are not allowed because they produce snagging hazards. The exceptions
to this are:

- Movable bridges at the expansion joints of the movable sections.
- At traffic gates and drop down net barriers.
- At stairways.
- Design F guardrail end sections will be used at the approach and trailing end of these gaps.

The following information will be needed from the Region Design office:

- Bridge Site Data Rehabilitation Sheet – Form # 235-002A.
- Photos, preferably digital Jpegs.
- Layout with existing dimensions.
- Measurements of existing ACP to top of curb, at the four corners as a minimum.
- Location of Type 3 anchors, if present.
- The proposed overlay type, quantities of removal and placement.
- For timber bridges, field measurement of the distance from the edge of bridge deck to the first and second stringer, for mounting plate modification.

Placement of the retrofit system will be determined from the WSDOT Highway Design Manual, Figure 710.15. Exceptions to this are bridges with sidewalk strength problems, pedestrian access issues, or vehicle snagging problems.

10.4.4 WSDOT Bridge Inventory of Bridge Rails

The WSDOT Bridge Preservation office maintains an inventory of all bridges in the state on the State of Washington Inventory of Bridges.

Concrete balusters are deficient for current lateral load capacity requirements. They have approximately 3 kips of capacity whereas 10 kips is required.

The combination high-base concrete parapet and metal rail may or may not be considered adequate depending upon the rail type. The metal rail Type R, S, and SB attached to the top of the high-base parapet are considered capable of resisting the required 5 kips of lateral load. Types 3, 1B, and 3A are considered inadequate. See WSDOT Highway Design Manual, Section 710 for replacement criteria.

10.4.5 Available Retrofit Designs

A. Washington Thrie Beam Retrofit of Concrete Balusters

This system consists of thrie beam guardrail stiffening of existing concrete baluster rails with timber blockouts. The Southwest Research Institute conducted full-scale crash tests of this retrofit in 1987. Results of the tests were satisfactory and complied with criteria for a Test Level 2 (TL2) category in the Guide Specifications. For complete details see details see Appendix 10.4-A1.

B. New York Thrie Beam Guardrail

This crash tested rail system can be utilized at the top of a raised concrete sidewalk to separate pedestrian traffic from the vehicular traffic or can be mounted directly to the top of the concrete deck. For complete details see Thrie Beam Retrofit Concrete Curb in Appendix 10.4-A1.

C. Concrete Parapet Retrofit

This is similar to the New York system. For complete details see Appendix 10.4-A1.

D. SL-1 Weak Post

WSDOT has utilized this design on some short concrete spans and timber bridges. A failure mechanism is built into this rail system so that upon impact, a 2 kip applied load, the post will break away from the mounting. The thrie beam guardrail will contain the vehicle by virtue of its ribbon strength. This failure mechanism assures minimal damage to the bridge deck and stringers. For complete details see Appendix 10.4-A1.

10.4.6 Available Replacement Designs

A. Traffic Barrier - Shape F Retrofit

This is WSDOT'spreferred replacement of deficient traffic barriers and parapets on high volume highways with a large truck percentage. All interstate highway bridges shall use this type. For complete details see Appendix 10.4-A2.

10.5 Bridge Railing

10.5.1 Design

WSDOT pedestrian and bike/pedestrian railings are design in accordance with Chapter 13 in the AASHTO LRFD Bridge Design Specifications.

10.5.2 Railing Types

A. Bridge Railing Type Pedestrian

This pedestrian railing is designed to sit on top of the 32" and 34" traffic barriers and to meet pedestrian height requirements of 42". For complete details see Appendix 10.5-A1.

B. Bridge Railing Type BP and S-BP

These railings are designed to meet the minimum bicycle height requirements of 54", and sit on top of the 32" and 34" traffic barriers. There are two versions. The BP is the standard railing and is made out of aluminum. The S-BP is the steel version designed for use in rural areas because of aluminum theft. For complete details see Appendix 10.5-A2 and 10.5-A3.

C. Pedestrian Railing

This railing is designed to sit on top of a six-inch curb on the exterior of a bridge sidewalk. It meets the bicycle height requirements of 54". For complete details see Appendix 10.5-A4.

D. Bridge Railing Type Chain Link Snow Fence

This is designed to minimize plowed snow from falling off the bridge on to traffic below. For complete details see Appendix 10.5-A5.

10.6 Bridge Approach Slabs

Bridge approaches typically experience two types of settlement, global and local. Global settlement is consolidation of the deeper natural foundation soils. Local settlement is mainly compression of fill materials directly beneath the approach pavement due to construction. The combination of global and local settlements adjacent to the bridge end piers form the characteristic "bump" in the pavement at the bridge. The approach slab significantly reduces local settlement and will provide a transition to the long term roadway differential settlements. Generally, abutments with a deep foundation will have greater differential roadway settlements than spread footing foundations.

When are Approach Slabs Required?

Bridge approach slabs are required for all new and widened bridges, except when concurrence is reached between the Geotechnical Branch, the Region Design Project Engineer Office, and the Bridge and Structures Office, that approach slabs are not appropriate for a particular site. In accordance with WSDOT Design Manual Chapter 1120, the State Geotechnical Engineer will include a recommendation in the Geotechnical Report for a bridge on whether or not bridge approach slabs should be used at the bridge site. Factors considered while evaluating the need for bridge approach slabs include the amount of expected settlement and the type of bridge structure.

Standard Plan A-2

The Standard Plan A-2 is available for the Local Agencies (or others) to use or reference in a contract. Bridge and Structures Office designs for local agency projects may reference Standard Plan A-2. However, detailed information in a customized approach slab Plan View is preferred.

Bridge Runoff

Bridge runoff at the abutments shall be carried off and collected at least 10 feet beyond the bridge approach slab. Drainage structures such as grate inlets and catch basins shall be located in accordance with Standard Plan A-4 and the recommendations of the Hydraulics Office.

Approach Pay Item

All costs in connection with constructing bridge approach slabs are included in the unit contract price per square yard for "Bridge Approach Slab". The pay item includes steel reinforcing bars, approach slab anchors, concrete, and compression seals. For the Contractor's information, the total quantity of epoxy-coated and plain steel reinforcing bars (lbs), concrete (SY), and miscellaneous items shall be listed in the bar list sheet for each bridge.

10.6.1 Notes to Region for Preliminary Plan

All bridge preliminary plans shall show approach slabs at the ends of the bridges. In the Notes to Region in the first submittal of the Preliminary Plan to the Region, the designer shall ask the following questions:

1. Bridge approach slabs are shown for this bridge, and will be included in the Bridge PS&E. Do you concur?
2. The approach ends of the bridge approach slabs are shown (a) parallel to the back of pavement seat (b) normal to the survey line (the designer shall propose one alternative). Do you concur?
3. Please indicate the pavement type for the approach roadway.

Depending on the type and number of other roadway features present at the bridge site (such as approach curbs and barriers, drainage structures, sidewalks, utilities and conduit pipes) or special construction requirements such as staged construction, other questions in the Notes to Region pertaining to the bridge approach slabs may be appropriate.

Special staging conditions exist when the abutment skew is greater than 30 degrees and for wide roadway widths. This includes bridge widenings with (or without) existing bridge approach slabs. The preliminary plan should include details showing how these conditions are being addressed for the bridge approach slabs, and the designer shall include appropriate questions in the Notes to Region asking for concurrence with the proposed design.

10.6.2 Approach Slab Design and Detailing

All bridge preliminary plans shall show approach slabs at the ends of the bridges. In the Notes to Region in the first submittal of the Preliminary Plan to the Region, the designer shall ask the following questions:

1. The bridge approach slab is designed as a slab in accordance with AASHTO LRFD. (Strength Limit State, IM = 1.33, no skew).
2. The support at the roadway end is assumed to be a uniform soil reaction with a bearing length that is approximately 1/3 the length of the approach slab, or 25ft /3 = 8 feet.
3. The Effective Span Length (S_{eff}), regardless of approach length, is assumed to be:

   25 foot approach - 8 feet/2 to CL soil support - 10 inch seat width = 20 feet
4. Longitudinal reinforcing bars do not require modification for skewed approaches or slab lengths greater than 25 feet.
5. BDM Section 7.4.3, Abutment Loading, provides slab reactions without a dynamic allowance (IM). A dynamic allowance, IM = 1.33, should be applied to the design of a pavement seat.
6. The maximum skew accommodated detailed in the standard sheets is 30 degrees.

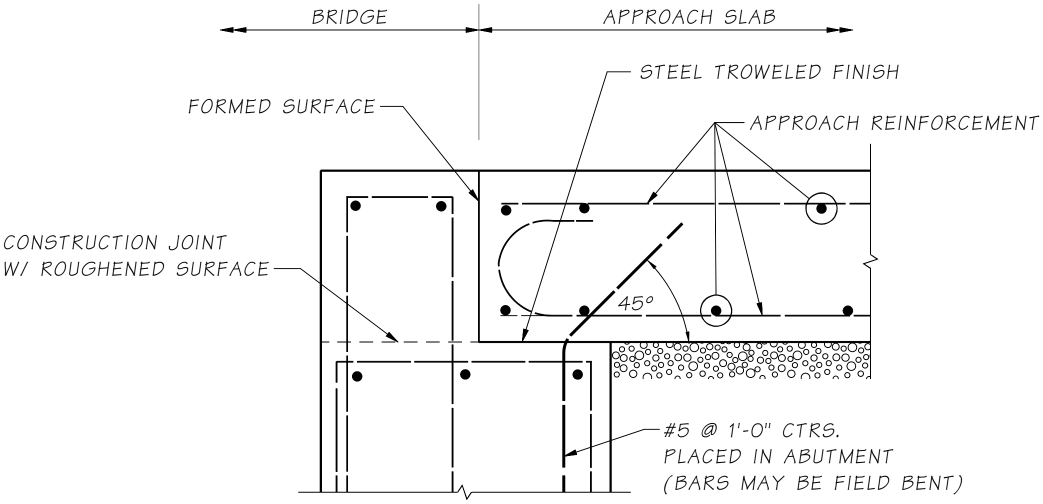
10.6.3 Approach Expansion Joints

For semi-integral abutments or stub abutments, the Bridge Designer must check the joint design to make sure the movement of the standard joint is not exceeded. In general, the approach slab is assumed to be stationary and the joint gap is designed to vary with the bridge movement. The BDM Approach Slab Sheet 10.6-A1.2 and Standard Plan A-2 detail a small compression seal with a 1-5/8 inch installed gap. Bridges with large expansion movements or highly skewed joints may require compression seals larger than the standard joint and are not recommended. If a larger seal is required, the approach seat should also be larger.

Approach slab anchors installed at bridge abutments should be as shown in the Bridge Plans. For bridges with semi-integral type abutments, this can be accomplished by showing the approach slab anchors in the End Diaphragm or Pavement Seat details.

L type abutments

L type abutments do not require expansion joints or approach anchors because the abutment and approach slab are both considered stationary. A pinned connection is preferred. The L TYPE ABUTMENT ANCHOR detail, as shown below, must be added to the abutment Plan Sheets. The pinned anchor for bridges with L type abutments shall be a #5 bar at one foot spacing, bent as shown, with 1’-0” embedment into both the pier and the bridge approach slab. This bar shall be included in the bar list for the bridge substructure.



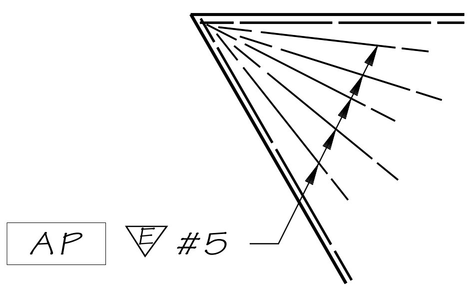
L Type Abutment Anchor Detail

Figure 10-14

10.6.4 Skewed Approach Slabs

For all skewed abutments, the roadway end of the bridge approach slab shall be normal to the roadway centerline.

The Bridge Supervisor should be consulted when approach slab skew is greater than 30 degrees or significantly wide (three lanes or more). These conditions will vary the required approach slab length. The roadway end of the approach may be stepped or staggered to reduce the size or to accommodate staging construction widths.



Flared Corner Steel

Figure 10-15

In addition, for bridges with skews greater than 30 degrees additional steel reinforcing bars shall be added to the acute corners of the bridge approach slabs. Typical placement is shown in the FLARED CORNER STEEL detail. The flared corner steel should be #5 rebar, 10 feet long, epoxy coated, and placed on top of the top layer of steel.

10.6.5 Bridge Approach Approach Detailing

The bridge approach slab and length along center line of project shall be shown in the Plan View of the Bridge Layout sheet. The Bridge Plans will also include approach slab information as shown on BDM Sheets 10.6-A1.1 and 10.6-A1.2. The Approach Slab Plan sheets should be modified as appropriate to match the bridge site conditions. Generally, both anchor types shown on the second sheet are not used on the bridge. The anchor not used should be deleted.

Additional details may be required to address special roadway features and construction requirements such as: roadway curbs and barriers, sidewalks, utilities and conduits and staging. This means, if sidewalks and interior barriers (such as traffic-pedestrian barriers) are present, special details will be required in the Bridge Plans to show how the sidewalks and interior barriers are connected to and constructed upon the bridge approach slab.

10.6.6 Pavement Seats on Existing Bridges

When approach slabs are added to existing bridges, the pavement seats may require modification. If the existing pavement seat is less than 10 inches, the seat shall be replaced with an acceptable, wider pavement seat. The Bridge Design Engineer may modify this requirement on a site-specific basis. Generic pavement seat repair details are shown in the BDM Sheet 10.6-A2.1 for a concrete repair and sheet 10.6-A2.2 for a steel T-section repair. These sheets can be customized for the project and added to the Bridge Plans.

10.7 Traffic Barrier on Approach Slabs

Placing the traffic barrier on the approach slab is beneficial for the following reasons.

- The approach slab resists traffic impact loads and may reduce wing wall thickness
- Simplified construction and conduit placement
- Bridge runoff is diverted away from the abutment

Most bridges will have some long-term differential settlement between the approach roadway and the abutment. Therefore, a gap between the approach slab and wing (or wall) should be shown in the details. The minimum gap is twice the long-term settlement, or 2 inches. A 3 inch gap is also acceptable as shown in Figure 10-16.

When the traffic barrier is placed on the approach slab, the following barrier guidelines apply.

- Barrier should extend to the end of the approach slab
- Bridge railing may stop near the point where the fill is at the same elevation as the grade
- Conduit deflection or expansion fittings must be called out at the joints
- Junction box locations should start and end in the approach
- The transverse top reinforcing in the slab meets the minimum steel requirements. This is not enough reinforcement to resist barrier collision forces. Therefore, a 6’-0” (hooked) #6 epoxy coated bar should be added to the approach slab as shown in Figure 10-16.

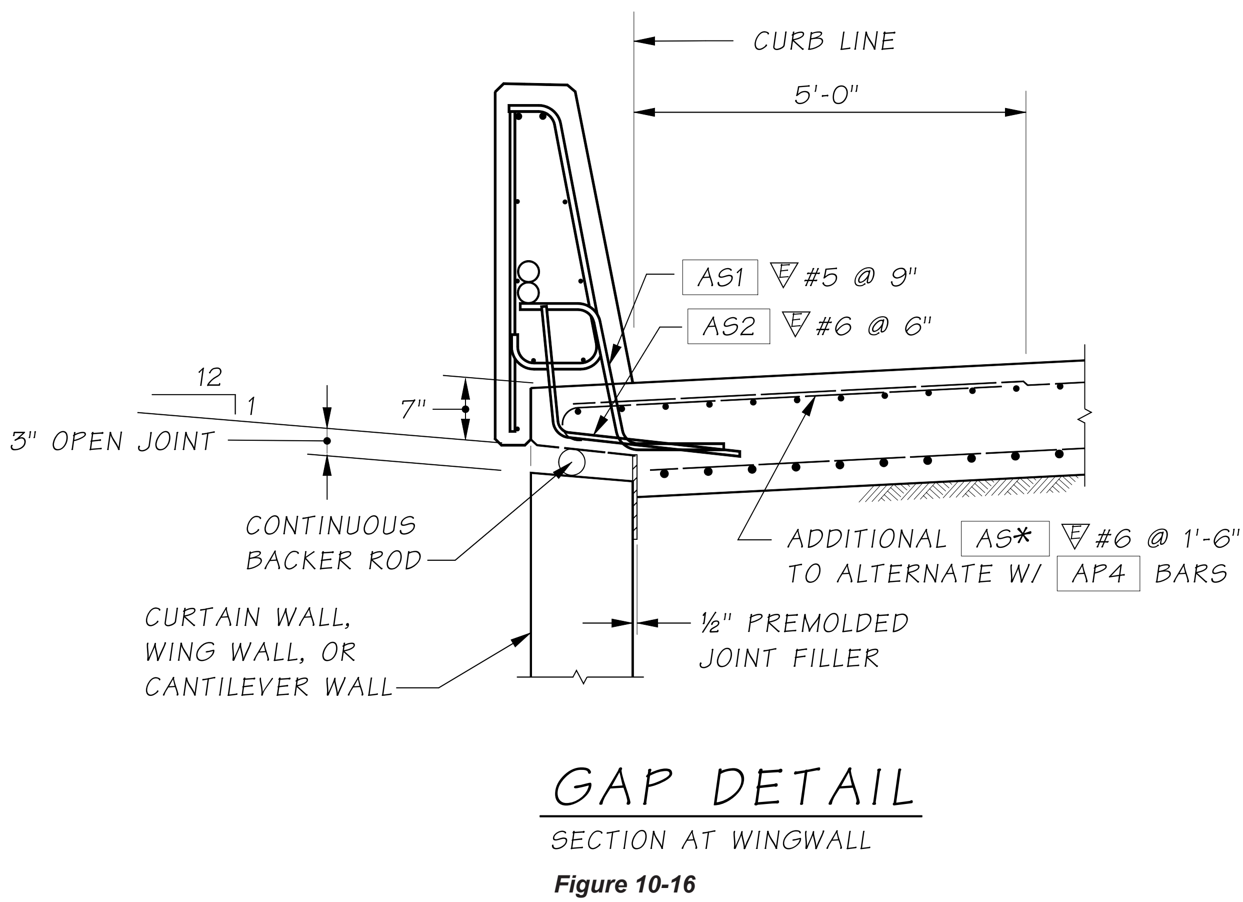


Figure 10-16

10.7.1 Approach Slab over Wing Walls, Cantilever Walls or Geosynthetic Walls

All walls that are cast-in-place below the approach slab should continue the barrier soffit line to grade. This includes geosynthetic walls that have a cast-in-place fascia. Figure 10-16 shows a generic layout at an abutment. Note the sectional Gap Detail, Figure 10-16, applies.

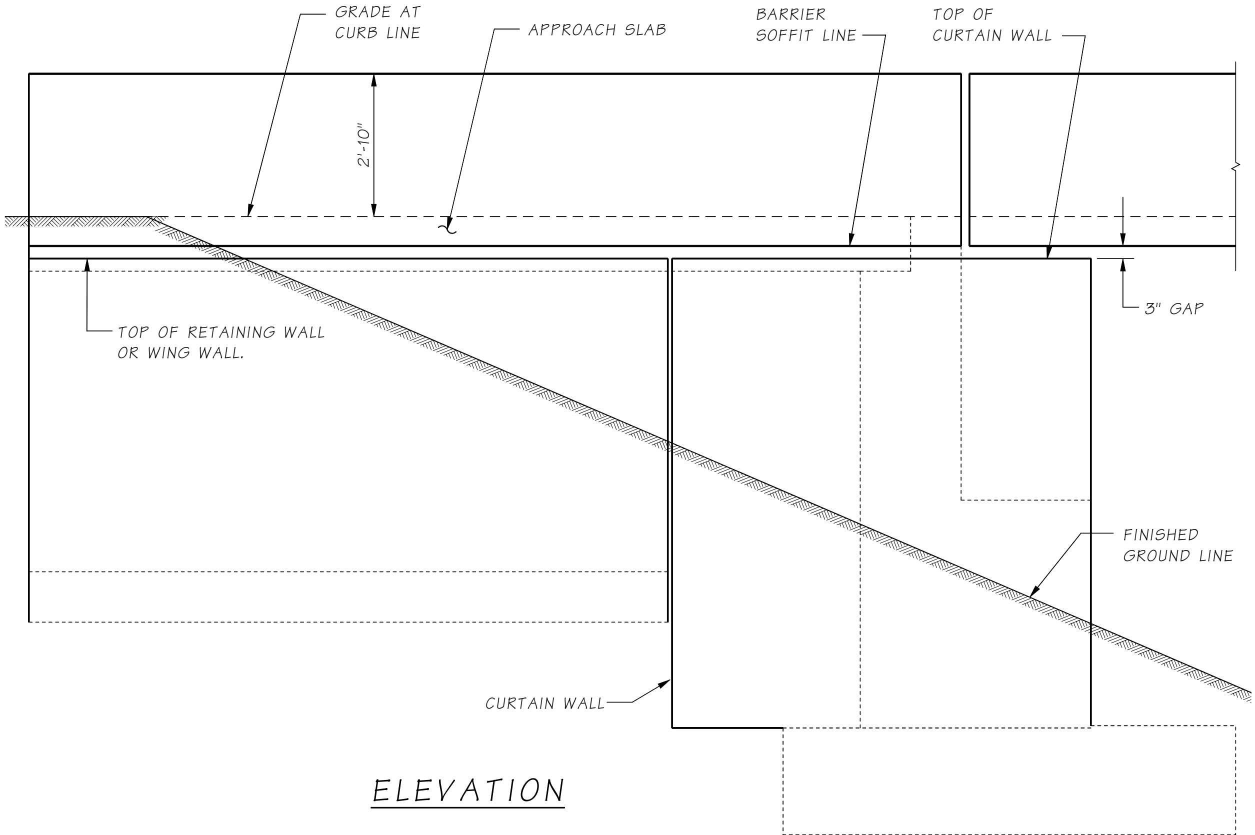


Figure 10-17

10.7.2 Approach Slab over SE Walls

The tops of Structure Earth (SE) walls are uneven and must be covered with a fascia to provide a smooth soffit line. Usually SE walls extend well beyond the end of the approach slab and require a moment slab. Since SEW barrier is typically 5’-0” deep from the top of the barrier, the soffit of the SEW barrier and bridge barrier do not match. The transition point for the soffit line should be at the bridge expansion joint as shown in Figure 10-19. This requires an extended back side of the barrier at the approach slab to cover the uneven top of the SE wall.

Battered wall systems, such as block walls, use a thickened section of the curtain wall to hide some of the batter. The State Bridge and Structures Architect will provide dimensions for this transition when required.

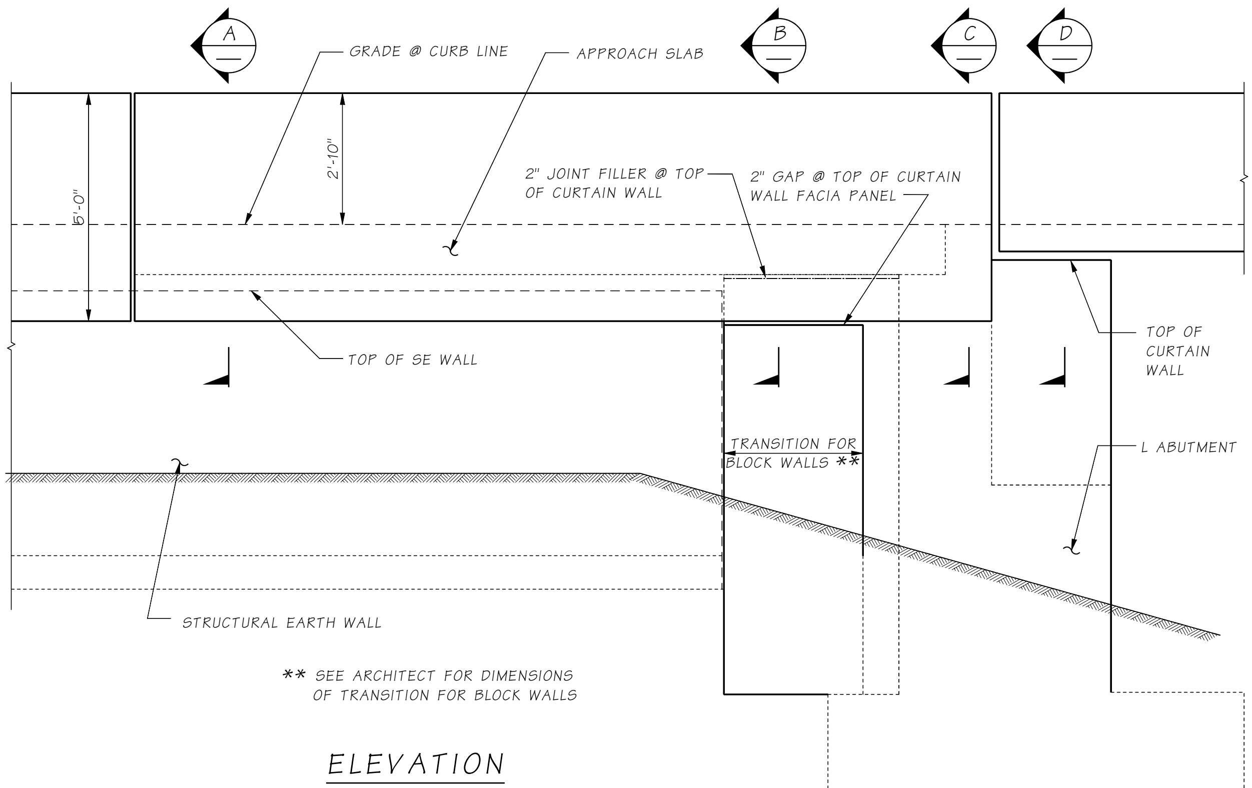


Figure 10-18

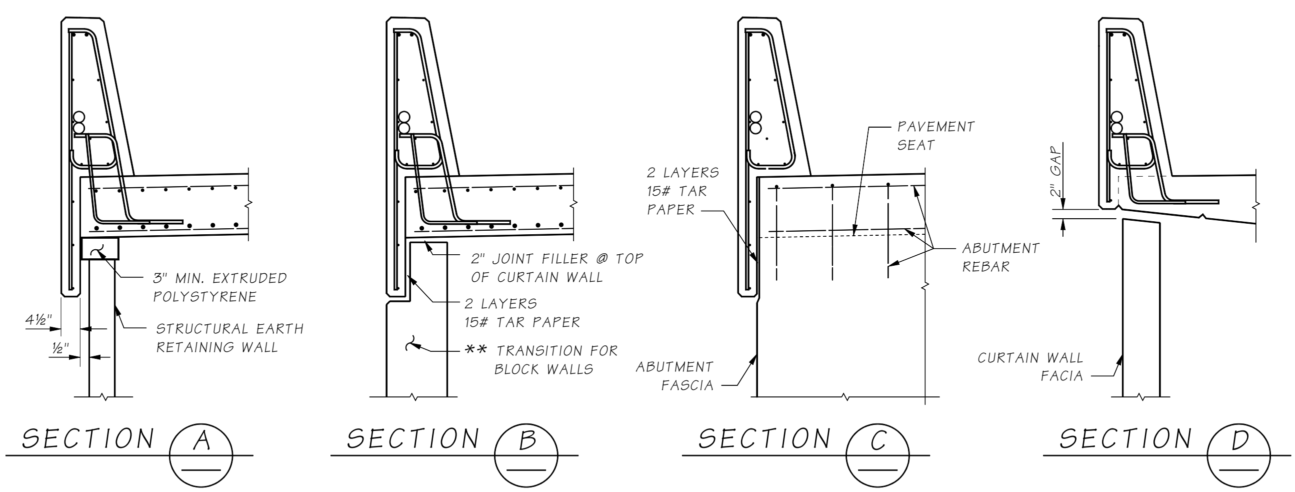


Figure 10-19

10.8 Utilities Installed with New Construction

10.8.1 General Concepts

The utilities to be considered under this section are electrical (power and communications) volatile fluids (gas), water, and sewer/storm water pipes. The Bridge designer shall determine if the utility may be attached to the structure and the location. Bridge plans shall include all hardware specifications and details for the utility attachment as provided in any written correspondence with the utility.

The Specifications Engineer will contact the Region Utility Engineer for additional design or construction requirements that may be stipulated in the utility agreement.

Responsibilities of the Utility Company

The Region or utility company will initiate utility installations and provide design information. The utility company shall be responsible for calculating design stresses in the utility and design of the support system. Utility support design calculations with, a State of Washington Profession Engineer stamp, shall be submitted to the Bridge and Structures Office for review. The following information shall be provided by the Utility Company and shown in the final Bridge Plans.

- Location of the utility outside the limits of the bridge structure
- Number of utilities, type, size, and weight (or Class) of utility lines
- Utility minimum bending radius for the conduit or pipeline specified

Utility General Notes and Design Criteria are stated in DOT Form 224-047 "General Notes and Design Criteria for Utility Installations". This form outlines most of the general information required by the Utility Company to design their attachments. The Bridge Office will generally provide the design for lightweight hanger systems, such as electrical conduits, attached to new structures.

Confined Spaces

A confined space is any place having a limited means of exit that is subject to the accumulation of toxic or flammable contaminants or an oxygen deficient environment. Confined spaces include but are not limited to pontoons, box girder bridges, storage tanks, ventilation or exhaust ducts, utility vaults, tunnels, pipelines, and open-topped spaces more than 4 feet in depth such as pits, tubes, vaults, and vessels. The designer should provide for the following:

- A sign with "Confined Space Authorized Personnel Only."
- In the "Special Provisions Check List," alert and/or indicate that a special provision might be needed to cover confined spaces.

Coating and Corrosion Protection

When the bridge is to receive pigmented sealer, consideration shall be given to painting any exposed utility lines and hangers to match the bridge. When a pigmented sealer is not required, steel utility conduits and hangers shall be painted or galvanized for corrosion protection. The special provisions shall specify cleaning and painting procedures.

10.8.2 Utility Design Criteria

All utilities shall be designed to resist Strength and Extreme Event Limits States. This includes and not limited to dead load, expansion, surge, and earthquake forces. Designers should review DOT Form 224-047 "General Notes and Design Criteria" and the items in this section when designing a utility system or providing a review for an existing bridge attachment.

The Bridge Engineer shall review the utility design to ensure the utility support system will carry all transverse and vertical loading. Loading will include (and is not limited to): Dead Load, Temperature expansion, dynamic action (water hammer), and Seismic inertial load.

Utility Location

Utilities should be located, if possible, such that a support failure will not result in damage to the bridge, the surrounding area, or be a hazard to traffic. In most cases, the utility is installed between girders. Utilities and supports must not extend below the bottom of the superstructure. Utilities shall be installed no lower than 1 foot 0 inches above the bottom of the girders. In some cases when appurtenances are required (such as air release valves), care should be taken to provide adequate space. The utility installation shall be located so as to minimize the effect on the appearance of the structure. Utilities shall not be attached above the bridge deck nor attached to the railings or posts.

Termination at the Bridge Ends

Utility conduit and encasements shall extend 10 feet minimum beyond the ends of the structure in order to reduce effects of embankment settlement on the utility and provide protection in case of future work involving excavation near the structure. This requirement shall be shown on the plans. Utilities off the bridge must be installed prior to paving of approaches. This should be stated in the Special Provisions.

Utility Expansion

The utilities shall be designed with a suitable expansion system as required to prevent longitudinal forces from being transferred to bridge members.

Water mains generally remain a constant temperature and are anchored in the ground at the abutments. However, the bridge will move with temperature changes and seismic forces. Pipe support systems must be designed to allow for the bridge movements. For short bridges, this generally means the bridge will move and the utility will not since it is anchored at the abutments. For long bridges that require pipe expansion joints, design must carefully locate pipe expansion joints and the corresponding longitudinal load-carrying support.

Electrical conduits that use PVC should have an expansion device for every 100 foot of pipe due to the higher coefficient of expansion. If more than two joints are specified, a cable or expansion limiting device is required to keep the ends from separating.

Gas Lines or Volatile Fluids

Pipeline carrying volatile fluids shall be designed by the Utility Company, in accordance with WAC 480-93-010. The pipeline material usually specified is Schedule 40 steel or Polyethelene (PE) pipe. All pipelines carrying volatile fluids shall be encased the length of the structure in steel encasement pipe and braced for lateral loading, see WAC 480-93-115 and Title 49 Code of Federal Regulations (CFR) Section 192.323, Transportation of Natural and Other Gas by Pipeline: Minimum Safety Standards. The space between the carrying pipe and the encasement sleeve shall be effectively vented beyond the structure at each end and at high points. Normally, the utility company will make provisions to electrically insulate the gas line from its support and vent the casing. Lines carrying other volatile materials shall be supported, as required by the utility, with due care taken to protect the structure and traffic.

Generally, a PVC sleeve approximately 3 inches larger than the outside diameter of the encasement pipe shall be used to pass the utility through concrete diaphragms or abutments.

Water Lines

Water lines shall be galvanized steel pipe or ductile iron pipe. Transverse support or bracing shall be provided for all water lines to carry Strength and Extreme Event Lateral Loading. Fire control piping is a special case where unusual care must be taken to handle the inertial loads and associated deflections. Normally, the Hydraulic Section will also be involved in this case.

In box girders (closed cell), a rupture of a water line will generally flood a cell before emergency response can shut down the water main. This will be designed for as an Extreme Event II load case, where the weight of water is a dead load (DC). Additional weep holes or open grating should be considered to offset this Extreme Event (see Figure 8.3.5-3).

Sewer Lines

Normally, an appropriate encasement pipe is required for sewer lines on bridges. Sewer lines must meet the same design criteria as waterlines. See the utility agreement or the Hydraulic Section for types of sewer pipe material typically used.

Telephone and Power Conduit

Generally, telephone, television cable, and power conduit shall be galvanized steel pipe or a PVC pipe of a UL approved type and shall be Schedule 40 or heavier. Where such conduit is buried in concrete curbs or barriers or has continuous support, such support is considered to be adequate. Where hangers or brackets support conduit at intervals, the distance between supports shall be small enough to avoid excessive sag between supports. See Section 10.8.7, Pipe Supports. Generally, the conduit shall be designed to support the cable in bending without exceeding working stresses for the conduit material.

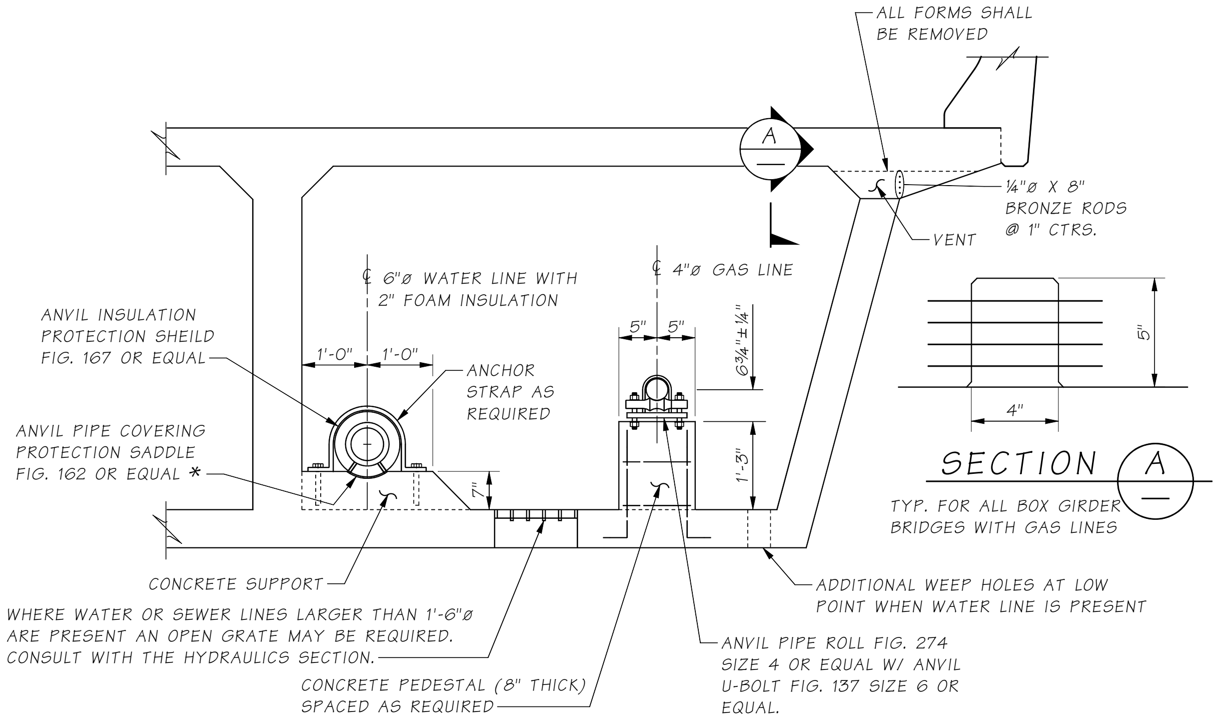
10.8.3 Box Girder Bridges

Internal illumination is required for steel box girder bridges, and appropriate conduit piper and fixtures shall be detailed as part of the bridge design. Girder cells with utilities must have access. Current practice for access is to locate hatches in the bottom flange. More than one hatch is usually required to access all sections of the cell in a bridge.

Access and ventilation shall always be provided in box girder cells containing gas lines.

Continuous Support and Concrete Pedestals

Special utilities (such as water or gas mains) in box girder bridges should use concrete pedestals. This allows the utility to be placed, inspected, and tested before the deck is cast. Concrete pedestals consist of concrete supports formed at suitable intervals and provided with some type of clamping device. A continuous support may be achieved by providing a ledge of concrete to support the conduit. Continuous supports should be avoided due to the very high cost and additional dead load to the structure.



CONCRETE UTILITY SUPPORTS

* SEE ANVIL PIPE HANGERS CATALOG

Figure 10-20

10.8.4 Traffic Barrier Conduit

All new bridge construction will install two (2) 2-inch galvanized steel conduits in the traffic barriers. These conduits generally carry wiring for Traffic Signals (TS) and Lighting (LT). Other wiring may be installed or the conduit may be used for future applications.

Conduits shall be stubbed-out at a concrete junction box provided in the Region Plans. The Bridge Plans must show the placement of the conduits to clear the structure or any foreseeable obstructions.

The galvanized steel conduit shall be wrapped with corrosion resistant tape at least one foot inside and outside of the concrete structure, and this requirement shall be so stated on the plans. The corrosion resistant tape shall be 3M Scotch 50, Bishop 5, Nashua AVI 10, or approved equal. The usual location of the conduit throughout the remainder of the bridge should be in the traffic barrier.

Pull boxes shall be provided at a maximum spacing of 180 feet. Their size shall conform to the specifications of the National Electric Code or be a minimum of 6 inches by 6 inches by 18 inches to facilitate pulling of wires. Galvanized steel pull boxes (or junctions boxes) shall me et the specifications of the "NEMA Type 4X" standard and shall be stated on the plans. Stainless steel pull boxes shall be allowed as an option to the galvanized steel.

In the case of existing bridges, an area 2 feet in width shall be reserved for conduit beginning at a point either 4 feet or 6 feet outside the face of usable shoulder. The fastening for and location of attaching the conduit to the existing bridge should be worked out on a job-by-job basis.

10.8.5 Conduit Types

All electrical conduits shall be Rigid Galvanized Steel (RGS) or PVC pipe, Schedule 40 or greater.

Steel Pipe

All steel pipe utility conduits shall be Schedule 40 or greater. All pipe and fittings shall be galvanized except for special uses.

PVC Pipe

PVC pipe may be used with suitable considerations for deflection, placement of expansion fittings, and of freezing water within the conduits. PVC pipe should not be placed in concrete traffic barriers due to damage and pipe separation that often occurs during concrete placement of slip formed barriers.

High Density Polyethylene (HDPE)

This material may be specified by some utilities. Unless other data is available, support as for PVC. Same restrictions to traffic barriers apply.

10.8.6 Utility Supports

The following types of supports are generally used for various utilities. Selection of a particular support type should be based on the needs of the installation and the best economy. All utility installations shall address temperature expansion in the design of the system or expansion devices.

Utility supports shall be designed so that a failure will not result in damage to the bridge, the surrounding area, or be a hazard to traffic. Utility supports shall be designed so that any loads imposed by the utility installation do not overstress the conduit, supports, bridge structure, or bridge members.

Designs shall provide longitudinal and transverse support for loads from gravity, earthquakes, temperature, inertia, etc. It is especially important to provide transverse and longitudinal support for Anvil inserts and other similar inserts that cannot resist moment.

The Bridge Engineer should request calculations from the utility company for any attachment detail that may be questionable. Utility attachments, which exert moments or large forces at the supports, shall be accompanied by at least one set of calculations from the utility company. Bridge attachments designed to resist surge forces should always be accompanied by calculations.

Concrete Embedment

This is the best structural support condition and offers maximum protection to the utility. Its cost may be high for larger conduit and the conduit cannot be replaced.

Pipe Hangers

Utility lines shall be suspended by means of cast-in-place anchors, whenever possible. This is the most common type of support for utilities to be hung under the bridge deck. This allows the use of standard cast-in-place inserts and is very flexible in terms of expansion requirements. For heavy pipes over traffic (10” water main or larger), a Safety Factor of 1.5 should be used to resist vertical loads for Strength design. This is to avoid complete failure of the utility hanger system by failure of one hanger. Vertical Anvil Insert, Figure 282 or similar inserts, will not provide resistance to longitudinal forces.

Transverse supports must be provided by a second hanger extending from a girder or by a brace against the girder. The BDM Sheets 10.8-A1.1 and 10.8-A1.2 depict typical utility support installations and placement at abutments and diaphragms.

Where PVC conduit is to be supported by hangers or pedestals at intervals, the distance between supports shall be small enough to avoid excessive sag of the conduit. For recommended support spacing and tabulated properties of PVC pipe, see Table 10-21.

PROPERTIES OF PVC PIPE

The following are recommended support spacings for PVC pipe.
(Ref: Western Plastics Corporation)

PVC Schedule 40

Nominal Size Inches	MM	O.D. Inches	MM	I.D. Inches	MM	Wall Thickness Inches	MM	Pounds Per 100 Feet	Newtons Per Meter	Recom. Support Spacing* (Feet)	(M)
¾	19	1.050	26.7	.824	20.9	.113	2.87	22.0	1.80	4	1.2
1	25	1.315	33.4	1.049	26.6	.133	3.38	32.0	2.67	4½	1.4
1¼	32	1.660	42.2	1.380	35.1	.140	3.50	43.5	3.61	5	1.5
1½	38	1.900	48.3	1.610	40.9	.145	3.68	52.0	4.31	5	1.5
2	51	2.375	60.3	2.067	52.5	.154	3.91	69.5	5.78	5	1.5
2½	64	2.875	73.0	2.469	62.7	.203	5.16	109.5	9.18	6	1.8
3	75	3.500	88.9	3.068	77.9	.216	5.49	143.0	12.0	6	1.8
4	102	4.500	114.3	4.026	102.3	.237	6.02	203.5	17.1	6½	2.0
5	127	(Use 5" PVC Class 200)						276.0	23.2	7	2.1
6	152	6.625	168.3	6.065	154.1	.280	7.11	359.0	30.1	7½	2.3
8	203	(Use 8" PVC Class 160)								8	2.4
10	254									8½	2.6
12	310									9½	2.9

PVC Schedule 80

Nominal Size Inches	MM	O.D. Inches	MM	I.D. Inches	MM	Wall Thickness Inches	MM	Pounds Per 100 Feet	Newtons Per Meter	Recom. Support Spacing* (Feet)	(M)
½	13	.840	21.3	.546	13.9	.147	3.73	20.5	1.72	4½	1.4
¾	19	1.050	26.7	.742	18.8	.154	3.91	28.0	2.34	4½	1.4
1	25	1.315	33.4	.957	24.3	.179	4.55	41.0	3.45	5	1.5
1¼	32	1.660	42.2	1.278	32.5	.191	4.85	56.5	4.76	5½	1.7
1½	38	1.900	48.3	1.500	38.1	.200	5.08	68.5	5.78	5½	1.7
2	51	2.375	60.3	1.939	49.3	.218	5.54	94.5	7.99	6	1.8
2½	64	2.875	73.0	2.323	59.0	.276	7.01	144.5	12.2	6½	2.0
3	75	3.500	88.9	2.900	73.7	.300	7.62	193.0	16.3	7	2.1
4	102	4.500	114.3	3.826	97.2	.337	8.56	282.0	23.8	7½	2.3
5	127	5.563	141.3	4.813	122.3	.375	9.53	392.0	33.0	8	2.4
6	152	6.625	168.3	5.761	146.3	.432	10.97	539.0	45.4	9	2.7
8	203									9½	2.9

*Spacings shown are set for a 100° maximum temperature.

The physical properties of PVC material are:

E = 410,000 psi
Tensile Strength = 7,300 psi at 78°F
Working Stress in Bending 4.0 k/in.^{2}
Temperature Coefficient - .035 inches per 100 degrees F per foot

Table 10-21

10.9 Utility Review Procedure for Installation on Existing Bridges

It is the responsibility of the Region Utilities Engineer to forward any proposed existing bridge attachments to the Bridge Preservation Office. The Bridge Preservation Office is responsible for reviewing only those details pertaining to the bridge crossing such as attachment details or trenching details adjacent to bridge piers or abutments.

The Bridge Preservation Office reviews proposed utility attachments and either approves the attachment or Returns For Correction (RFC). A current file for most utility attachments is maintained in the Bridge Preservation Office. The turnaround time for reviewing the proposals should not exceed two weeks; however, most attachments that have simple connections with epoxy anchors can be reviewed, stamped, and responded to within one day. This is provided that corrections and additional notes are minimal.

Occasionally, a utility company will request a conceptual approval of their proposed attachment before they invest their time in detailed drawings and calculations. Often they will request this approval by sending a sketch of their proposal directly to the Bridge Office. A letter of response will be sent directly to the utility that concurs with their proposal or suggests an alternate. This letter includes instructions for them to resubmit their final proposal through the Region Utilities Engineer with a courtesy copy of this letter sent to the Region Utilities Engineer.

The Region determines the number of copies to be returned. Most Regions send five copies of the proposed utility attachment. If the proposal is approved, Bridge Preservation will file one copy in the Utility file and return four marked copies. If it has been returned for correction or not approved, one copy is placed in the utility file and two marked copies are returned, thru the Region, to the Utility. See BDM Section 10.9.1, “Utility Review Checklist”.

Utility attachments, which exert moments or large forces at the supports, should be accompanied by at least one set of calculations from the utility company. Bridge attachments designed to resist surge forces should always be accompanied by calculations. The engineer may request calculations from the utility company for any attachment detail that may be questionable.

The engineer shall check the utility company’s design with his own calculations. The connection detail shall be designed to successfully transfer all forces to the bridge without causing overstress in the connections or to the bridge members to which they are attached. For large utilities, the bridge itself shall have adequate capacity to carry the utility without affecting the live load capacity.

Guidelines for Utility Companies

Detailing guidelines for utility companies to follow when designing utility attachments are listed in DOT Form 224-047, “General Notes and Design Criteria for Utility Installations to Existing Bridges”. Commonly used systems are detailed in the BDM Sheet 10.9-A1.1, “Utility Installation Guideline Details for Existing Bridges”.

10.9.1 Utility Review Checklist

This checklist applies to all proposed utility attachments to existing bridges.

1. Complete cursory check to become familiar with the proposal.
2. Determine location of existing utilities.
    a. Check Bridge Inspection Report for any existing utilities.
    b. Check Bridge Preservation’s utility file for any existing utility permits or franchises and possible as-built plans.
    c. Any existing utilities on the same side of the structure as the proposed utility should be shown on the proposal.
    d. Obtain as-built plans from bridge vault if not in an existing utility file.

3. Review the following with all comments in red:
   a. Layout that includes dimension, directions, SR number and bridge number.
   b. Adequate spacing of supports.
   c. Adequate strength of supports as attached to the bridge (calculations may be necessary).
   d. Maximum design pressure and regular operating pressure for pressure pipe systems.
   e. Adequate lateral bracing and thrust protection for pressure pipe systems.
   f. Does the utility obstruct maintenance or accessibility to key bridge components?
   g. Check Location (elevation and plan view) of the utility with respect to pier footings or abutments. If trench limits encroach within the 45° envelope from the footing edge, consult the Materials Lab.
   h. Force mains or water flow systems may require encasement if they are in excavations below the bottom of a footing.
4. Write a letter of reply or email to the Region so that a copy will be returned to you indicating that the package has been accepted and sent out.
5. Stamp and date the plans using the same date as shown on the letter of reply or email.
6. Create a file folder with the following information:
   a. Bridge no., name, utility company or utility type, and franchise or permit number.
   b. One set of approved plans and possibly one or two pages of the original design plans if necessary for quick future reference. Previous transmittals and plans not approved or returned to correction should be discarded to avoid unnecessary clutter of the files.
   c. Include the letter of submittal and a copy of the letter of reply or email after it has been accepted.
7. Give the complete package to the section supervisor for review and place the folder in the utility file after the review.

10.10 Drainage Design

Even though it is rare that poor drainage is directly responsible for a structural failure, it still must be a primary consideration in the design. Poor drainage can cause problems such as ponding on the roadway, erosion of abutments, and deterioration of structural members. Collecting the runoff and transporting it away from the bridge can prevent most of the problems. Proper geometrics during the preliminary stage is essential in order to accomplish this. The Hydraulics Section recommends placing the bridge deck drainage off of the structure. Therefore, the Bridge Design Section has adopted the policy that all expansion joints will be watertight.

Geometrics

Bridges should have adequate transverse and longitudinal slopes to allow the water to run quickly to the drains. A transverse slope of .02′/ft. and longitudinal slope of 0.5 percent for minimum valves are adequate. Avoid placing sag vertical curves and superelevation crossovers on the structure that could result in hydroplaning conditions or, in cold climates, sheets of ice from melting snow. The use of unsymmetrical vertical curves may assist the designer in shifting the low point off the structure.

Hydrology

Hydrological calculations are made using the rational equation. A 10-year storm event with a 5-minute duration is the intensity used for all inlets except for sag vertical curves where a 50-year storm intensity is required.

On Bridge Systems

Where bridge length and geometry require a bridge drain system within the bridge, the first preference is to place 5-inch diameter pipe drains that have no bars and drop straight to the ground. At other times, such as for steel structures, the straight drop drain is unacceptable and a piping system with bridge drains is required. The minimum pipe diameter should be 6 inches with no sharp bends within the system.

Construction

Bridge decks have a striated finish in accordance with the Standard Specifications listed below, however, the gutters have an untextured finish (steel trowel) for a distance of 2 feet from the curb. This untextured area provides for smooth gutter flow and a Manning n value of .015 in the design.

Standard Specification Section 6-02.3(10) — Bridge Decks

Standard Specification Section 5-05.3(11) — Approach Slabs